U. S.

REPORT OF PROCEEDINGS

Conference on Agricultural Processing Wastes

November 1 and 2, 1954

Conference was held at the Eastern Utilization Research Branch with representatives from Industry, the State Agricultural Experiment Stations, Universities, State and Interstate Water Control Commissions, State Departments of Health, the U. S. Department of Health, Education and Welfare, the Federal Extension Service, Military, and the U. S. Department of Agriculture participating.

This report summarizes the discussions of the various speakers during the conference. If further details regarding any particular subject are desired, they may be obtained by communicating with the person concerned (see appended list of names and addresses).

Ia
I Eastern Utilization Research Branch
U. S. Agricultural Research Service,
U. S. Department of Agriculture
5a Philadelphia, 18, Pennsylvania

PROGRAM

Monday, November 1

9:45 a.m. Introductory Remarks — P. A. Wells, Chief, Eastern Utilization Research Branch

FEDERAL AND STATE ACTIVITIES

10:00 a.m.

U. S. Public Health Service Activities in Industrial Waste — L. F. Warrick, Department of Health, Education and Welfare, Washington, D. C.

10:30 a.m. Discussion

10:40 a.m.

The New England Interstate Water Pollution Control Commission -- Stream Classification — Joseph C. Knox, Secretary, Boston, Massachusetts

11:10 a.m. Discussion

11:20 a.m.

Industrial Waste Control in Pennsylvania --Effluent Control and Industry Standards — F. B. Milligan, Department of Health, Harrisburg, Pennsylvania

11:50 a.m. Discussion of all three papers

12:30 p.m. LUNCH

GENERAL PROBLEMS OF TREATMENT AND UTILIZATION

2:00 p.m.

Evaluation of Process Variables for Industrial Waste Design — W. Wesley Eckenfelder, Jr., Manhattan College, New York, New York

2:30 p.m. Discussion

3:00 p.m.

Byproduct Recovery vs. Waste Treatment — Sam R. Hoover, Eastern Utilization Research Branch

3:30 p.m. Discussion

Monday, November 1 (continued)

4:00 p.m.

Requirements for Proposed New Animal Feeds from Industrial Wastes	S. B. Randle Agricultural Experiment Station New Brunswick, New Jersey

4:30 p.m. Tour of the Laboratories

Tuesday, November 2

FRUIT AND VEGETABLE PROCESSING WASTES

9:00 a.m.

Spray Irrigation of Cannery Wastes	L. F. Warrick Department of Health, Education and Welfare Washington, D. C.

9:30 a.m. Discussion

10:00 a.m.

Recovery and Utilization of Tomato Processing Wastes	P. W. Edwards Eastern Utilization Research Branch

10:30 a.m. Discussion

11:00 a.m.

Utilization of Pear Wastes	A. H. Brown Western Utilization Research Branch Albany, California

11:30 a.m. Discussion

12:00 Noon LUNCH

MEAT AND DAIRY PROCESSING WASTES

1:30 p.m.

Anaerobic Treatment of Meat Packing Wastes	A. J. Steffen Wilson and Company Chicago, Illinois

2:00 p.m. Discussion

2:30 p.m.

Aerobic Treatment of Dairy Wastes	Nandor Porges Eastern Utilization Research Branch

3:00 p.m. Discussion

Tuesday, November 2 (continued)

3:30 p.m.

Dairy Waste Treatment at The Pennsylvania State University	R. R. Kountz Pennsylvania State University State College, Pennsylvania

4:00 p.m. Discussion

4:30 p.m. Adjournment

INTRODUCTORY REMARKS

by

P. A. Wells, Eastern Utilization Research Branch

Dr. Wells welcomed the delegates to the laboratory. He pointed out that the present meeting constituted the annual State Agricultural Experiment Station Collaborators Conference for the Eastern Region. The Maryland Experiment Station had suggested that a conference on Agricultural Processing Wastes be held, and the Directors of the Experiment Stations for the Eastern Region at their Spring meeting held in Wilmington, Delaware, indicated that this subject would be a suitable one for the collaborators.

In order to take advantage of the broad interest in this subject, representatives from other State and Federal agencies, universities and industrial organizations were also invited to participate.

U. S. PUBLIC HEALTH SERVICE ACTIVITIES IN INDUSTRIAL WASTE

by

L. F. Warrick, Department of Health, Education and Welfare
Washington, D. C.

Dr. Warrick reviewed the activities of the Public Health Service under Public Law 845, the Water Pollution Control Act of 1948, with special emphasis on the research activities in industrial wastes.

Industrial waste research is supported and fostered by the Public Health Service in three principal ways: first, by grants to organizations or individuals for fundamental research through the National Institutes of Health; second, by grants to States or interstate agencies for industrial-waste studies in connection with the water pollution control program; and third, by direct engagement in research and field investigations pertaining to industrial-waste problems through the Environmental Health Center at Cincinnati. At present the second of these phases is greatly restricted because of lack of funds.

The National Technical Task Committee on Industrial Wastes was organized by industry in 1950, on invitation of the Surgeon General. It is an advisory committee to the Public Health Service and serves to collect and coordinate information on industrial waste problems and their solution.

(Summary prepared by S. R. Hoover)

THE NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION -- STREAM CLASSIFICATION

by

Joseph C. Knox, Secretary, Boston, Massachusetts

Before describing the composition and activities of the Commission provided for in the New England Compact, the need for such a Compact, precedents for it, and how its ratification was brought about were discussed briefly.

The area embraced by the New England Compact includes 65,000 square miles with a population of about 9,200,000 and is the second most densely populated area in the United States. It is the most highly developed industrial area in the western hemisphere and its economy rests on the base of 24,000 manufacturing plants, their $15 billion output and their $5 billion total annual payroll. The industries are diversified with textiles, metal products, paper and leather goods being the leading products manufactured.

It is estimated by the State water pollution control agencies that there are over 800 communities discharging untreated sewage directly into the waters of the Compact area from a contributing population of over 6,600,000. The industrial waste picture, as portrayed by a survey sponsored by the Commission, indicates that there are over 1,900 plants producing industrial wastes. The total pollution load from manufacturing plants discharging untreated organic wastes into our waters is equivalent to the wastes from over 4,500,000 persons. In addition, there is further degradation of water quality from inorganic and toxic wastes from metal, chemical and other manufacturing plants.

The Commission, which consists of five representatives from each of the signatory States, administers the New England Interstate Water Pollution Control Compact. The manner in which the Commissioners are chosen and their terms of office are specified in the ratification legislation of each State. Several of the Commissioners are State officials in charge of departments or divisions concerned with pollution control, and the others are appointees of the Governors. The membership of the Commission provides representation of the many interests involved in pollution control, including public health, conservation, engineering, industry and the legal profession. An important adjunct to the Commission is a Technical Advisory Board which is composed of the directors of the State pollution control agencies, under whose direction the technical phase of the work is conducted. The Commission is financed by annual appropriations from the signatory States, based on the population and valuation of each State within the Compact area.

Recognizing the necessity of a balanced use of our waters to meet the various degrees of water quality required for the proper maintenance of our social and economic well-being, the Compact is built around a classification of waters according to recommended highest use. This classification system, which is based on accepted water quality standards, reconciles the conflict of water uses by the assignment of classifications which are deemed to be in the best interests of the public, after due consideration of all factors involved.

The Tentative Plan for Classification of Waters, which has been adopted by the Commission, defines the classes of water according to (1) suitability for use and (2) standards of quality, as shown in the accompanying table. This concept of stream classification on the basis of reasonable use is an idea that has existed in both State and Federal circles for a great many years. It has been reported that of the 22 States which have revised their pollution control laws within recent years, 16 of them have done so on the stream classification basis.

In general, the classification systems of the New England States and New York State correspond with that of the Commission and can be readily expressed in terms of the Compact's classification plan. This is one of the reasons why the Compact standards are in broad terms and are not as specific in detail as

in some of the States. Under the terms of the Compact, each signatory State agrees to prepare classifications of its interstate waters according to present and proposed highest use and to submit them to the Commission for approval. After approval by the Commission, preceded in each case by a public hearing conducted by the Commission or the States concerned, the States are pledged under the terms of the Compact to establish programs of treatment of sewage and industrial wastes to bring about the improvements required to meet the approved classification. The Commission has no authority to issue orders for pollution abatement. Such powers are retained by the individual States and used when needed to enforce classification requirements. The Commission is in effect an agency of the signatory States, coordinating a mutually agreed upon plan to improve and control the quality of our waters for their most beneficial uses. The Compact provides the mechanism whereby the States can solve the problems of interstate water pollution control through a long-range program conducted in well coordinated steps.

To date the Commission has approved classifications for several river basins where serious interstate pollution problems exist.

For detailed information on the names of these rivers and the particular problems imposed, it is suggested that you write directly to Mr. Knox.

In conclusion, the classification of waters is proving to be an effective approach to the problems of both intrastate and interstate water pollution control in the New England Compact area. Classification provides a framework for effectively presenting a composite picture of the present condition of a river and the ultimate water quality objectives to be achieved. It presents a feasible and economic plan for pollution abatement, incorporating both the results of comprehensive studies by the regulatory agencies and the desires of the inhabitants and of the conservation, recreational and industrial interests as expressed at public hearings and group conferences. Classification focuses publicity on the problem by providing the citizens and their municipal leaders, and the industries and other groups concerned, a definite basis for supporting remedial measures. It has been said that classification of waters would still be a well justified procedure if it served no useful purpose other than informational and educational.

Discussion

In reply to a question about the bacteriological phases of the A and B stream classifications, Mr. Knox indicated that consideration was given only to Coliform bacteria. Dr. M. S. Anderson pointed out that soil carried into streams by erosion was high in organic content and accordingly had a high B.O.D. value.

NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION

TENTATIVE PLAN FOR CLASSIFICATION OF WATERS

(As Revised and Accepted December 8, 1950)

	Class A	Class B	Class C	Class D
		SUITABILITY FOR USE		
	Suitable for any water use. Character uniformly excellent.	Suitable for bathing and recreation, irrigation and agricultural uses; good fish habitat; good aesthetic value. Acceptable for public water supply with filtration and disinfection.	Suitable for recreational boating, irrigation of crops not used for consumption without cooking; habitat for wildlife and common food and game fishes indigenous to the region.	Suitable for transportation of sewage and industrial wastes without nuisance, and for power, navigation and other industrial uses.
		STANDARDS OF QUALITY		
Dissolved oxygen	Not less than 75% sat.	Not less than 75% sat.	Not less than 5 p.p.m.	Present at all times
Oil and grease	None	No appreciable amount	Not objectionable	Not objectionable
Odor, scum, floating solids, or debris	None	None	None	Not objectionable
Sludge deposits	None	None	None	Not objectionable
Color and turbidity	None	Not objectionable	Not objectionable	Not objectionable
Phenols or other taste producing substances	None	None	None	
Substances potentially toxic	None	None	Not in toxic concentrations or combinations	Not in toxic concentrations or combinations
Free acids or alkalies	None	None	None	Not in objectionable amounts
Coliform bacteria	*Within limits approved by State Department of Health for uses involved.	Bacterial content of bathing waters shall meet limits approved by State Department of Health and acceptability will depend on sanitary survey.		

**Sea waters used for the taking of market shellfish shall not have a median coliform content in excess of 70 per 100 ml.*

NOTE: Waters falling below these descriptions are considered as unsatisfactory and as Class E.
These standards do not apply to conditions brought about by natural causes.
For purpose of distinction as to use, waters used or proposed for public water supply shall be so designated.

INDUSTRIAL WASTE CONTROL IN PENNSYLVANIA - EFFLUENT CONTROL AND INDUSTRY STANDARDS

by
F. B. Milligan, Pennsylvania Department of Health
Harrisburg, Pennsylvania

The 100,000 miles of streams in Pennsylvania supply 90% of its domestic and industrial water supply; hence pollution control is essential.

Wastes from most water-using industries (except mineral and chemical) result from raising and processing agricultural products. Decaying and unstable substances are present, such as juices and plant particles from canneries; cellulose and sulphite liquor from paper and pulp mills; tan liquor with particles of hide, hair and lime from tanneries; milk solids, whey or skim milk from milk plants; fibers, dyes, grease, sugars from textile mills; and wastes from farming.

The Sanitary Water Board operates under the Stream Pollution Control Law. Specific controls are provided covering discharge of industrial wastes, as well as sewage, to the waters of the Commonwealth. The technical personnel of the Board are members of the Sanitary Engineering Bureau of the Health Department.

The program of the Board requires the treatment of sewage and industrial wastes to a specified degree before discharge into streams; treatment varies with the diverse conditions of the streams. Streams are grouped on the basis of their use and condition into those requiring primary, complete or other degrees of treatment. Blanket minimum requirements of reduction from untreated wastes are established for every town and industry on a given stream based on the use and condition of that watercourse. Additional treatment is required if necessitated by the use or condition of the stream. The Board may change the category of a stream or a portion of it when warranted by changes in use or condition of the stream or by the progressive improvement program.

Primary treatment requires the removal of practically all settleable solids and at least 35% of the B.O.D., plus removal of toxic and other objectionable substances. Complete treatment requires additional removal of all suspended solids and at least 85% of the B.O.D. Intermediate treatment is defined in accordance with the need in each instance. Plans for works to provide the required degree of treatment must be approved by the Board.

Effluent standards provide tools for use in protection of public waters and restoration to cleanliness and are based on unit quantities of material processed. Standards for milk wastes and pulp and paper mill wastes were adopted and are available. These standards establish values for B.O.D. and solids for each type of process.

Determination of equitable requirements for the stream, based solely on its condition after receiving the effluents, necessitates the obtaining of much data and the making of many arbitrary rulings. The point in the stream, as well as the stream stage at which requirements are to be enforced, must be fixed arbitrarily, and the velocity of flow at this critical stage must be

determined. Account must be taken of artificial and natural admixing as well as initial high oxygen demand of the wastes, which may cause oxygen depletion or form a barrier against the passage of fish.

Other criteria must be established. The practicability of biological surveys as a basis for stream standards to supplement chemical and biochemical determinations are under study.

The Sanitary Water Board after careful consideration established its present requirements, a compromise between one extreme of arbitrary percentage reduction for all sources of pollution and the opposite extreme of requirements based only on the estimated or determined assimilating power of the receiving stream.

EVALUATION OF PROCESS VARIABLES FOR INDUSTRIAL WASTE DESIGN

by

W. Wesley Eckenfelder, Jr., Manhattan College
New York, New York

Wastes from the food processing industries are largely organic in nature, composed principally of carbohydrates, fats and proteins. Several methods have been developed for the disposal of these wastes; namely, chemical coagulation with alum or ferric chloride, biological treatment in fixed or fluid beds, and land disposal by spray irrigation or lagooning. Chemical treatment will remove only colloidal or suspended organic matter. For wastes where a large portion of the B.O.D. is in soluble form, this treatment is limited in application. Land disposal of food processing waste by spraying has proven an economical and effective method in areas where land is available and soil conditions are favorable. Where the aforementioned methods are not applicable, biological treatment is usually the most economical method of waste disposal.

Before the biological treatment system can be designed consideration must be given to methods of reducing, segregating, utilizing or recirculating waste water or waste matter. After these measures have been taken, process evaluation for treatment can be made in five basic steps:

(a) Industrial waste survey to establish the basic pollution abatement problem.

(b) Engineering surveys to define the layout and physical aspects of the industrial plant.

(c) Studies to explore utilization, segregation or recirculation of waters and wastes.

(d) Process development to establish a sound basis for treatment of remaining wastes.

(e) Process design to render the most economical plant from previously derived data.

An industrial waste survey is conducted to derive the basic information necessary for the design of pollution abatement facilities. This includes a comprehensive quantitative study of the plant and the receiving stream and a qualitative process survey of the plant to establish the type, location and various sources of pollution.

Factors of significance to be considered in the quantitative survey are (a) the chemical nature of the waste, (b) the volume of the waste, (c) the frequency and variation of discharge.

The method and frequency of sampling in industrial waste surveys is important to insure representative data for future design. Sampling may be done either manually or automatically. Continuous sampling is usually more desirable and should be used wherever possible. Frequency of sampling depends largely on the nature and variability of the waste and on the significant waste characteristics being investigated. Waste flow rate data can be obtained from measurements made by any of several metering devices.

In characterizing the waste, oxygen demand, solids, flow, and nutritional content (nitrogen and phosphorus) are necessary factors to determine the waste treatment plant design, while characteristics such as pH, temperature, toxic elements, etc., are vital to the design of process control mechanisms. Simplified analytical procedures are desirable for laboratory analysis and control. For example, the C.O.D. test may frequently be substituted for the B.O.D. of volatile solids test provided a significant correlation can be established between the two characteristics.

When the survey is complete, the data may be correlated, checked, and the primary design basis for waste treatment, elimination and utilization evolved by use of a process materials balance. The net sum of waste constituents from each individual source throughout the industrial plant is balanced against the total waste discharge from the plant. The variables usually selected to derive this balance are determined by the nature of the process and the requirements for disposal. Statistics are applicable for the analysis of data which involve variation and provide a method for the significant interpretation of these data for design purposes.

Waste flows and loadings may be frequently correlated to units of production, thus enabling extrapolation to any anticipated production schedule for future design needs. For example, tomato waste flow and loading have been correlated to the number of washing rigs in operation. By the aforementioned correlation, waste treatment requirements for any future production schedule can be anticipated.

The flow and material balance diagram and the statistical analysis of waste survey data are employed to show possible sources of elimination or reduction of the quantity of waste matter or waste water. A reduction of this nature may be accomplished by the following methods:

1. Recovery or utilization of waste products.
2. Removal of waste matter in a dry state.
3. Segregation of non-contaminated waste water.
4. Recirculation of waste waters.

In process development for waste treatment, laboratory oxidation studies may be employed to establish B.O.D. removal and oxidation rates, sludge accumulation, oxygen utilization, and nutritional requirements. It is important in conducting such studies that a sludge be acclimated to the particular waste before quantitative studies are made. This can be accomplished by aerating the waste with activated sludge from a domestic sewage plant for several days.

Further process studies employing a continuous treatment pilot plant may be employed to confirm process data. Experience has shown that pilot plant data are translatable to prototype design. Operating variables from the pilot plant can be statistically analyzed to establish the design basis for basin size and equipment. The concepts discussed in this paper are equally applicable to the design of trickling filters but have not been evaluated quantitatively to the same extent.

References:

Eckenfelder, W. W., and O'Connor, D. J., "Industrial Waste Process Design," Proc., ASCE 80, 411, Feb. 1954

Eckenfelder, W. W., "Aeration Efficiency and Design," Sew. and Ind. Wastes 24, 10, 11, Oct.-Nov. 1952

BYPRODUCT RECOVERY VS. WASTE TREATMENT

by

Sam R. Hoover, Eastern Utilization Research Branch

It is necessary in planning research on either of these two problems that the aim of the work be clearly understood. To many people the word "waste" means "useless or unnecessary expenditure"; the true meaning in this field is "refuse, especially that from any manufacturing process." In the field of waste disposal or treatment one must understand clearly that there are processing wastes which are unavoidable and that the primary aim of research in this field is to treat these wastes so that they will not cause stream and/or air pollution.

The State and Federal regulations for the protection of the public health require that food processing equipment be cleaned in a rigorous manner and that the residual food drained and washed from equipment not be used for food purposes. This is the first type of unavoidable waste in food processing. In the dairy industry it amounts to about 0.5% of the milk processed. There are also losses due to faulty connections, spillage, and the occasional batch of inedible product caused by off-flavor, spoilage, etc. The latter type of losses can be kept down by good plant operation, but cannot be eliminated because they result from the normal, human mistakes that people make. A waste disposal system that does not take this latter factor into account will be a failure in operation.

The point must be emphasized repeatedly that there are food processing wastes that cannot be avoided and that the primary aim of research in this field is elimination of pollution from these wastes at the lowest cost.

Byproduct research, on the other hand, is an effective way of reducing processing costs, and even of making substantial profits. From the viewpoint of waste disposal, any byproduct operation must be considered in the same way as the other plant operations. It may reduce the amount of wastes which require treatment or it may increase them appreciably. For example, the recovery of fermentation-spent grains and solubles for sale as animal feeds has been both a valuable byproduct operation and has substantially reduced waste treatment in the distilling industry. On the other hand, the production of animal feeds by blanching, pressing, and drying field wastes of vegetable crops increases the effluent markedly.

Byproduct recovery of food products must be considered with especial care in relation to waste disposal. As stated above, any food processing operation must contribute to the waste disposal problem. Many non-food byproduct recoveries also produce liquid wastes. The costs of waste disposal from such operations must be considered in the cost estimate and the resulting calculations must indicate that the process is economically valuable before a byproduct operation can be considered to be a sound investment.

In summary, it is postulated that waste disposal studies and byproduct recovery investigations are two distinct lines of research, each of which has its own merits. A byproduct operation seldom is an answer to the waste disposal problems in a plant, and often increases the liquid effluent. The most satisfactory way to attack waste disposal problems is by directly working on inexpensive processes which produce a high degree of treatment, and the best way to attack byproduct recovery problems is to work on economically sound product development. There is not much to be gained by confusing these two sound objectives.

REQUIREMENTS FOR PROPOSED NEW ANIMAL FEEDS FROM INDUSTRIAL WASTES

by
S. B. Randle, Agricultural Experiment Station
New Brunswick, New Jersey

Dr. Randle discussed the requirements for new animal feeds from the viewpoint of the State Chemist. The State Chemist is responsible for administering and enforcing laws dealing with Feed, Fertilizer, Economic Poisons and Liming Materials. His functions go beyond those of an enforcement officer in that he is frequently called upon to act in the capacity of adviser or consultant. Dr. Randle pointed out the tremendously increased population in this country and its shift from rural to urban locale. These factors, coupled with an increasing tendency of urban dwellers to demand foods in convenient processed form, will increase the amount of agricultural wastes to be disposed of. These must be utilized in feeds to an increasing extent to supply the needs of an expanding population. Examples of valuable feed wastes not formerly utilized are:

Distillers dried grains
Distillers dried solubles
Fish meal
Condensed and dried fish solubles
Dried citrus pulp and beet pulp
Antibiotic waste

Rapid developments in animal nutrition were mentioned, for example, the utilization of new materials for feed--urea for ruminants, antibiotics and drugs for growth and disease prevention, low quality roughages such as corn cobs and straw supplemented with urea and molasses.

Waste agricultural residues for use in feed must meet the following requirements of industry and/or regulatory control:

1. Constant and uniform supply
2. Freedom from toxic substances
   a. Those inherent in material
   b. Those added during processing
   c. Those present as spray residue
3. Economy
4. Nutritive value
5. Palatability
6. Stability
7. Tested biologically and chemically

Discussion

Question: Does the State Chemist influence the drafting of bills dealing with feeds?

Answer: Yes, but the final law may be quite different from the original bill.

Comment by R. H. Morris, 3rd: Cattle have been killed by eating wastes grown in Florida containing such trace elements as molybdenum and selenium.

Comment by Dr. H. A. Trebler, Retired Research Director of National Dairies: It is important that the feed stuff contribute no off-flavor to dairy products.

Question: Is there any market at present for feed components not in a dry state?

Answer: Yes; if these possess properties of special value they can be incorporated into dry feeds, for example, condensed whey and condensed fish solubles are also employed.

SPRAY IRRIGATION OF CANNERY WASTES

by

L. F. Warrick, Department of Health, Education and Welfare
Washington, D. C.

The disposal of liquid wastes on land is a successful way of treating food processing wastes in many circumstances. The two basic methods used are ridge and furrow irrigation and spray irrigation, both of which have developed from conventional agricultural irrigation practice.

The essential requirements for successful use of spray irrigation are (1) available land, (2) type of soil, and (3) cover crop. It seems to be especially well adapted to plants that operate in the summer and fall, although year-round use of spray irrigation even in the northern states and Canada is being investigated.

The furrow irrigation at California Fruit Exchange and spray disposal at Seabrook Farms were described and shown in color slides. The first of these operations is conducted as part of an integrated farming operation. A definite return in the form of increased productivity of the farm, that at least partially offsets the cost of disposal, is indicated. The major part of the Seabrook waste is sprayed in woodland; however, disposal on one-year old asparagus and some row crops has been beneficial.

Typical spray treatment systems for smaller canneries and dairy plants were described by N. H. Sanborn in Sewage and Industrial Wastes 25, 1034-43 (1953). General recommendations for the utilization of this type of treatment are given there.

(Summary prepared by S. R. Hoover)

RECOVERY AND UTILIZATION OF TOMATO PROCESSING WASTES

by

Paul W. Edwards, Eastern Utilization Research Branch

This report briefly covers work done at the Eastern Utilization Research Branch on a process for disposing of tomato wastes. We realized that the cost to produce a feed from the total waste would probably exceed its sale value. Each year in this country about 3 million tons of tomatoes are processed, largely into juice and juice products. Almost one-fifth of this appears in the form of waste products. These wastes are low in solids. Our work was directed toward avoiding stream pollution by recovering the wastes and converting them to a feed product.

A plant large enough to justify our waste recovery system should have a capacity of about 26,000 tons of tomatoes per season, and about 800 tons per day during the peak of the season. Of course, several smaller plants could use one waste recovery system. The wastes arise from two sources. From the food pulpers come tailings which consist largely of skins and seeds. The tailings contain about 85% water. The other source of waste is culls and trimmings. These can be processed to produce tailings and a juice containing about 95% water.

It was found that the tailings after pressing could be satisfactorily dried in a direct fired, multi-pass, rotary, alfalfa drier. The optimum drying conditions were obtained with an inlet air temperature of 1050°F. and exit gas temperature of 275°F. The drier when operated under these conditions produced a product light in color and having a pleasing fresh odor. This material, although high in fiber (about 30%), is rich in protein (22.5%) and fat (14%). For some years the demand for this product has exceeded the supply.

Even if all the cake were dried there still remains the problem of disposing of 90 tons a day of the combined liquors from the presses and the waste pulper. The solids in these liquors are about equal to the solids from the press cake. It was found that 83% of the total waste solids could be recovered in the form of feed in the following manner. The waste liquors were concentrated to 30% solids, then mixed with the dried press cake and the mixture dried in the rotary drier. Because of the tacky nature of the mixture the maximum inlet gas temperature which could be used was about 550°F. with an exit temperature of 235°F.

The chief differences in this product over that of the dried press cake alone are an increase in carbohydrate content (33.4%) with a significant reduction in fiber (22%) and slight reduction in protein (21%) and fat (10%).

The capital investment for such a plant would be about $88,000 with $25,000 working capital, that is a total of $113,000. The cost to make a ton of product is estimated to be about $115. This includes factory cost, overhead, interest on working capital and administrative and general expense. It is quite probable that the product is not worth that much. However, feeding tests with broilers indicate it might be worth $75 a ton. Obviously there is no profit motive here. However, it does appear promising as a means of waste disposal. Assuming a loss of $40 per ton of dried product, the annual cost for disposing of 83% of the waste solids would be about $10,000. This amounts to about 3/4 cent per case of juice from the food plant. It thus appears that a plant no longer able to dump its wastes may well find this recovery system the cheapest means of waste disposal.

For details of the process see "Recovery of Tomato Processing Wastes," Edwards, Eskew, Hoersch, Aceto and Redfield, Food Technology, 1952, Vol. VI, No. 10, pages 383-386.

Utilization

Some years ago Dr. C. M. McCay, Professor of Nutrition, Cornell University, discovered that when dried tomato press cake, commonly called tomato pomace, was added to dry dog feed it prevented diarrhea when fed to dogs. Prior to that time there was only a small demand for tomato pomace. Today the demand for this product from the dog feed industry alone exceeds the supply.

In order to determine the value of our waste tomato products, plans were made whereby Dr. McCay conducted the dog feeding tests at Cornell. This was done under a memorandum of understanding among this laboratory, the Seaboard Supply Company and Cornell University.

The results of these tests showed the dried mixture of concentrate and dried tomato pomace to be as effective or better than dried tomato pomace alone for use in dog feeds in the prevention of diarrhea and constipation. McCay also made growth studies with Beagle puppies fed tomato pomace and the dried mixture of pomace and concentrate to determine if the mixture contained any injurious substance. He concluded that it is believed from both present and past experience that there is no injurious substance in either form of pomace.

Broiler Feed Tests: Two series of feeding tests were made under a memorandum of understanding between the Eastern Utilization Research Branch and the

Delaware Agricultural Experiment Station. In the first experiment, using 686 chicks, the control diet contained 5% wheat middlings. In the test rations the wheat middlings was replaced by the same amount of (a) dried tomato press cake, (b) dried mixture of press cake and concentrate and (c) dehydrated alfalfa meal. The following conclusions were reported: The dried tomato press cake is highly significantly superior to the alfalfa meal and the tomato press cake plus concentrate and superior to wheat middlings. The tomato press cake appears to be a superior growth promoting product. The differences between alfalfa meal, wheat middlings and tomato press cake with concentrate were not significant.

In the second test, with 362 chicks, four diets were used: (a) Positive control-practical broiler mash, (b) Negative control-high corn broiler mash, (c) Five percent tomato press cake, and (d) Five percent press cake plus concentrate. In diets (c) and (d) the dried tomato wastes replaced some of the added ground yellow corn. The following conclusions were reported: Experiment 2 confirms the observations made in Experiment 1 that tomato pomace and tomato pomace with concentrate are very satisfactory ingredients for broiler diets. The broilers from Experiment 2 were even more satisfactory than those from Experiment 1. The differences were not significant, but the tomato pomace diet produced superior results again and approached significance at the 5% level.

These tests show that dried tomato wastes are valuable constituents in dry dog feed and broiler rations. While the sales value of the dried mixture of concentrate and pomace does not equal the cost of its recovery, the proceeds should greatly reduce the cost of tomato waste disposal in areas where dumping is not permitted.

UTILIZATION OF PEAR WASTES

by

A. H. Brown, Western Utilization Research Branch
Albany, California

Importance of the waste problem in the Santa Clara, California, area is indicated by the fact that about 40% of the pears canned in the United States are packed here. As an example, about 50,000 tons of waste were derived from some 120,000 tons of pears during a 60-70 day season in 1950.

To move such loads through the sewage treating systems is unsound because of the short season. Consequently, land dumping of the waste has been practiced for many years. A disposal method that includes utilization has been an important objective for engineering and chemical research.

In 1949, an industry-government research team undertook the development of a practical process for converting pear-cannery waste to salable products. The Western Utilization Research Branch supplied chemical engineers and chemists, while the Canners League of California and the Cling Peach Advisory Board provided plant facilities, a plant superintendent, an operating crew and funds to attack the problem on a pilot-plant scale.

Previous studies showed that lime treatment was a promising method for altering the fresh ground pear waste to facilitate separation of juice from pomace. Addition of lime to pH 11 causes alkaline deesterification of the pectin and formation of a calcium pectate gel in the waste.

With aging, the gel synerizes and clear juice is released. The treated, aged waste can be pressed in a bag or rack-and-frame press, to produce a clear juice and a press cake that can be dried without difficulty. Batch pressing is, however, too expensive for use on fruit wastes. A number of commercially available continuous presses that looked promising were tried but found to be unsatisfactory. Pear waste, either with or without treatment, is too soft and deficient in actual fiber to be pressed satisfactorily in conventional types of continuous presses.

Further studies showed that enzymatic deesterification of the pectin in the waste was more easily controlled than was alkaline deesterification from the standpoint of subsequent juice separation.

The enzyme pectinesterase occurs naturally in pear waste, and it rapidly deesterifies the pectin if a proper environment is provided--pH 7 to 9 and temperature 70-100°F. Addition of lime to the waste not only provides a suitable pH, but the calcium ion catalyzes the deesterification reaction and combines with the pectic acid to form a gel which synerizes readily. A second addition of lime and heating of the waste further condition the material for dejuicing.

While these studies were in progress a continuous filter was constructed of wood. It comprised two filter-surface-faced drums, designed to turn together from the top, and provided with a cover into which treated waste is pumped under low pressure. Juice runs through the filter surfaces and is collected from the interiors of the drums. Cake is deposited on the filter surfaces. As the two drums turn, the two filter cakes are pressed together, and a dejuiced cake is discharged from between the drums.

From the information obtained a commercial-size dejuicing press was constructed having drums 4 feet long and 4 feet in diameter.

Later, a continuous treater was developed to provide optimum chemical and physical conditions for conditioning the waste prior to dejuicing. Effectiveness of the improved waste treatment, combined with the continuous treater, was demonstrated by the fact that the capacity of the dejuicing press was increased at least 50 percent. The pomace having a moisture content of 73-74 percent is then dried. The juice is concentrated in triple effect evaporators, then mixed with the dried pulp and the mixture used for feed.

Feeding tests with cattle and sheep using pear pomace and pear molasses showed that both feeds are highly palatable and produced satisfactory gains.

Given reasonable prices for feed materials, pear cannery waste may now be profitably utilized for the production of stock feeds.

Discussion

Question: Is it proposed to use the new continuous press for pressing apples?

Answer: Funds are not available for investigating its use with apples. However, preliminary tests on apples indicated considerable promise.

ANAEROBIC TREATMENT OF MEAT PACKING WASTES

by

A. J. Steffen, Wilson & Co., Inc., Chicago, Illinois

The first studies in anaerobic digestion of meat packing plant wastes were undertaken in 1949 on a barrel scale at the Hormel Packing Plant in Austin, Minnesota, by W. J. Fullen, Research Chemist. Until that time anaerobic digestion had been limited to treatment of stronger wastes, particularly wastes from the fermentation industries. However, the relatively high temperature (about 85°F.) of packing plant wastes and their high volatile solids content (1200 to 2000 p.p.m.) were found to be distinct advantages in anaerobic digestion. In the early work, entrained gases in the sludge prevented separation of the treated liquor by conventional sedimentation, and satisfactory effluents could not be guaranteed.

In 1952 the American Meat Institute's Committee on Meat Packing Waste Disposal became interested in the process and employed Prof. George J. Schroepfer of the University of Minnesota to evaluate the process and suggest further research. With the combined efforts of Mr. Fullen, Prof. Schroepfer and members of the committe, possibilities of improving sludge separation by degasification and by the use of fly ash as a weighting additive were investigated and a large scale pilot plant, including a 940 cu. ft. digester, was built.

Vacuum degasification proved successful at vacua of 18" to 26" but addition of fly ash, although technically successful, was abandoned because of mechanical difficulties which would be encountered in a full scale plant.

Typical packing plant effluents are successfully treated after ten hours digestion with a reduction of 94% in B.O.D. and a 90% removal of suspended solids at loadings of 0.15 to 0.22 lbs. B.O.D. per cubic foot of digester capacity per day, and a digestion temperature of 95°F. Turbulent mixing and high solids concentration (about 13,000 to 14,000 p.p.m. suspended solids) in the digester and rapid removal of settled sludge from the separator are essential features of the process. This type of plant can be built for about 2/3 the cost of a conventional two-stage trickling filter plant handling packing plant wastes. Operating costs are slightly higher than for a trickling filter plant because of power requirements in mixing and degasification. Auxiliary fuel will also be necessary under certain conditions of temperature and volatile solids content, since these two variables control the gas production.

AEROBIC TREATMENT OF DAIRY WASTES

by

Nandor Porges, Eastern Utilization Research Branch

Milk processing plants produce wastes consisting of residual milk washed from cans, coolers, pumps and other equipment as well as that lost by leakage and spillage. Accepted operating loss is 1% of milk handled, although losses may be greater. A plant handling 100,000 pounds of milk daily will discharge as waste 1000 pounds of fluid milk containing 100 pounds milk solids, which is diluted by wash water to a concentration of 0.1% or 1000 parts per million (p.p.m.) solids. This waste water has 800 p.p.m. B.O.D. and has about 5 times the polluting strength of municipal sewage. The daily pollution load will equal that of 320 people.

Dairy waste is an excellent nutrient for bacteria causing deficiency of available oxygen and inducing obnoxious anaerobic conditions harmful to higher life and esthetically distasteful to man. If sufficient air is available, 50% of the organic matter (measured as chemical oxygen demand, C.O.D.) is biologically oxidized and the resulting sludge cells are removable, yielding a clear effluent. If aeration continues, the sludge proceeds to oxidize itself. The first or assimilation phase occurs rapidly and requires 37.5% of the total oxygen. The second or endogenous phase in which the sludge digests itself proceeds much slower and uses oxygen at only about one-tenth the rate of the assimilation phase. Laboratory tests using only 500 p.p.m. sludge and 1000 p.p.m. skim milk show the first step to be completed in 6 hours. Higher concentration of sludge will shorten this time. The second step may take 100 hours.

Chemical equations were established showing the production of sludge cells from lactose, casein and skim milk. These products are completely assimilated and oxidized, producing only water and carbon dioxide. Such complete use occurs only if sufficient aeration is available to satisfy the oxygen requirements of the rapidly growing assimilative cells. Incomplete aeration and conversion produces difficulties.

Cooperative studies with Pennsylvania State University, being carried out under contract, are aimed at solving engineering difficulties. A simple aerobic biological treatment has been designed and can be used for rapid disposal of milk and other agricultural wastes.

DAIRY WASTE TREATMENT AT THE PENNSYLVANIA STATE UNIVERSITY

by

R. Rupert Kountz, Pennsylvania State University
State College, Pennsylvania

Two years ago The Pennsylvania State University (Department of Engineering Research) undertook a research project to develop the dairy waste treatment theories and laboratory data of Hoover and his associates at the Eastern Utilization Research Branch, Philadelphia. This project involved the construction of a flexible-design waste treatment plant for the wastes from the

University Creamery. After 20 months of operation the original research data of Hoover et al. have been fully substantiated, and the information which follows is based on these studies. Through the efforts and interest of Dr. David Levowitz, Director, New Jersey Dairy Laboratories, New Brunswick, N. J., the author designed the first commercial prototype for the Port Murray Dairy Co., Port Murray, N. J. This plant has been operating satisfactorily since April 12, 1954. The second prototype has started operation at Flemington, N. J., for the Johanna Farms dairy. These installations show that a treatment plant properly designed to employ bio-oxidation can remove 95% of the milk solids content in waste water and do it without excessive costs or nuisances.

This project has developed the following information: (1) Milk solids can be oxidized in a few hours to carbon dioxide and water, without any odor, providing sufficient oxygen is made available. This means that each ten pounds of milk lost or spilled requires 1.5 pounds of oxygen dissolved in the waste during treatment. In the ratings below, the use of a quantity or rate of air supplied per weight of milk lost is avoided because different aerating devices dissolve oxygen with varying efficiencies:

Mechanical	3-5 lbs. oxygen/hr/Horsepower
Diffusers	2.5 lbs. oxygen/hr/Horsepower
Ejector and blower	1.3 lbs. oxygen/hr/Horsepower
Ejector (alone)	1.0 lb. oxygen/hr/Horsepower

No work has been done under this project to date with mechanical aerators, but the above value is converted from the manufacturers' reports and also obtained by private correspondence with consultants. Although more power is needed with the ejector, the freedom from clogging is a definite asset in terms of maintenance cost. The Penberthy Ejector was found most satisfactory and the XL-96 type, size 7A (steam nozzle) is a convenient size to use. Its rate is given as lbs. oxygen/hr equals $0.165\ V^{2.35}$ where V is the nozzle flow in cfs divided by the nozzle diameter in feet. The oxygen supply is obtained by direct aspiration. If air is supplied by means of a blower at an air rate twice the water flow, this will increase the rate at which oxygen is dissolved by 50%.

(2) Excess sludge (bacterial cells) is no problem, as the sludge can be oxidized to carbon dioxide and water if desired. (If a market can be developed for the sludge, a portion can be withdrawn daily and concentrated, in view of its vitamin B_{12} content.) The total weight of cells is fixed, because a unit weight of milk solids produces half its weight in new cells and pilot plant data show that both old and new cells are oxidized endogenously at a rate between 20% per day (90°F.) and 10% per day (70°F.). This means that under steady state conditions the total weight of cells is 2.5 to 5.0 times the average weight of milk solids received per day in the waste.

(3) Cheese whey can be oxidized in the same manner as milk, providing its protein deficiency is supplied.

The problem with whey is really a problem of oxidizing a 6% lactose solution. Bacteria oxidize the lactose for the energy they need to convert protein or ammonia into new cell material. If no protein is present the lactose is not needed and remains untouched by the bacteria, and thus no treatment occurs.

The protein deficiency of whey can be made up by adding ammonium sulfate, ammonia or urea to the waste to be treated. One pound of ammonia is equivalent to 10 pounds of casein for the purpose of lactose oxidation, and six lbs. of ammonia per 1000 lbs. of whey is sufficient. In a dairy which makes cheese occasionally, the use of an ammonia supplement will permit satisfactory operation and treatment of the whey.

(4) Treatment plants can be designed either as fill-and-draw units for small dairies, or as continuous flow units for large dairies.

Work at the University pilot plant and that now going on at Harrington Dairy Co., Dushore, Pa., as well as observations of existing plants, dictates the preferred use of a fill-and-draw or batch type of treatment whenever possible. If a continuous flow plant is needed, the aeration tank must be baffled to secure a true displacement flow and allow the incoming waste to contact only completely oxidized sludge.

How to Figure Plant Size. Assume a 100,000 lb. per day dairy plant whose process losses are equivalent to 2.5% of the milk received. Also assume a total waste volume of 25,000 gal. in 8 hrs. with an average B.O.D. value of 1000 p.p.m. Daily loss of 2,500 lbs. of milk corresponds to an equilibrium total sludge weight of 750 lbs.

Waste treatment tank volume is based on the volume of compacted cells and volume of waste to be treated per day. The 750 lbs. of sludge occupies 600 cu. ft. when settled. This volume plus one foot of freeboard is the sedimentation portion of the treatment tank and will be assumed in this example to be 1,200 cu. ft. To this is added the volume of the day's waste, namely 3,300 cu. ft., giving a total treatment tank volume of 4,530 cu. ft., or 34,000 gal. The effluent pipe is located at the 9,000 (1,200 cu. ft.) gallon level.

In this type of plant the oxygen supply is stopped for 6 hours to allow cells to settle, after which the 25,000 gal. of clear supernatant liquid drains out. The bacterial flora is not harmed by this 6-hour period during which no oxygen is supplied. In addition, the bacterial flora can be inoculated from an activated sludge sewage plant if desired, but it will develop naturally from the waste in ten days to two weeks of operation.

Calculating Oxygen Demand. The rate of endogenous oxidation is uniform and is determined from weight of cells oxidized per day. In this case 150 lbs. (one-half the weight of milk solids) are oxidized per day, requiring 12.5 lbs. dissolved oxygen per hour for 18 hours.

The assimilation phase, based on a milk loss of 315 lbs. per hr. (37.5 lbs. milk solids per hr.), will require dissolved oxygen at the rate of 17 lbs. per hr. During the 8 hours of waste flow, dissolved oxygen must be supplied at the rate of about 30 lbs. per hr. (17 lbs. per hr. plus 12.5 lbs. per hr.), and during the remaining time at a rate of 12.5 lbs. per hr. The excess air supply for waste assimilation must be stopped when the waste flow ceases or else foaming problems will be encountered.

Preliminary Cost Estimates. Assuming that land area is available adjoining the dairy and the topography permits gravity flow throughout the treatment

system, the imaginary plant for our 100,000 lbs. per day dairy can be built at a cost of approximately $10,000. The power requirements would be approximately 500 HP-hours per day, or an estimated cost of $6.00 per day for power. Assuming a fifteen-year life for the treatment plant the total cost would be approximately $8.00 per day. It is calculated that a 75,000 lbs. per day receiving station would require a $5,000 treatment plant and a power cost of $3.00 per day, with a total cost of $4.00 per day. In contrast, a "miniature sewage plant" for a 100,000 pound dairy might cost $30,000 to $40,000 to build. The total daily cost, including an "operator" for 20-30 hours per week, could easily amount to $16.00 per day.

In summary, the simplest type of treatment plant is a single tank having a volume of 150% of the daily waste volume. The screened waste flows into the suction line of the pump powering the ejector-air-diffusers during the day. During the night the air supply ceases automatically and two hours later the clear liquid (which contains less than 5% of the milk lost in the day's operation) is decanted. After effluent discharge, the air supply resumes, and in the morning the waste flows in again and the cycle resumes. Personnel time is 30 minutes per day to clean the screen and perform mechanical maintenance.

In the operation of this process there is no odor, no sludge disposal, no personal decisions nor laboratory tests. Milk wastes are the simplest, easiest wastes to treat because milk is the perfect food--for man and for bacteria.

LIST OF ATTENDANCE

Name	Organization	Address
Anderson, E. E.	Agricultural Experiment Station	Amherst, Mass.
Anderson, E. O.	Agricultural Experiment Station	Storrs, Conn.
Anderson, M. S.	Agricultural Research Service, USDA	Beltsville, Md.
Barrett, P.	Merck and Co., Inc.	Danville, Pa.
Beidler, J. W.	C. H. Musselman Co.	Biglerville, Pa.
Best, C. N.	Pennsylvania State University	State College, Pa.
Bonham, W. S.	Wm. Laning & Son	Bridgeton, N. J.
Brittingham, W. H.	Virginia Truck Experiment Station	Norfolk, Va.
Brown, A. H.	Western Utilization Research Branch	Albany, Calif.
Canham, R. A.	National Canners Association	Washington, D. C.
Cobble, J. W.	Agricultural Experiment Station	Kingston, R. I.
Connelly, E. J.	Southern Packing Co.	Baltimore, Md.
Cooley, R. M.	Shoreland Freezers, Inc.	Salisbury, Md.
Corse, W. F.	Charles G. Summers, Jr., Inc.	New Freedom, Pa.
Davis, J. G.	Western Utilization Research Branch	Albany, Calif.
Eagleson, J. R.	American Stores Co.	Philadelphia, Pa.
Eckenfelder, W.W., Jr.	Manhattan College	New York, N. Y.
Edwards, P. W.	Eastern Utilization Research Branch	Philadelphia, Pa.
Eskew, R. K.	Eastern Utilization Research Branch	Philadelphia, Pa.
Farber, H.	Wawa Dairy Farms	Wawa, Pa.
Fehmerling, G. B.	Fehmerling Associates	Bridgeton, N. J.
Fenelon, E. S.	H. J. Heinz Co.	Pittsburgh, Pa.
Fischer, H. O.	Campbell Soup Company	Camden, N. J.
Forney, C.	Pennsylvania State University	State College, Pa.
Fuller, C.	Phillips Packing Co., Inc.	Cambridge, Md.
Geddes, W. F.	University of Minnesota	St. Paul, Minn.
Gilbert, J. J.	Link Belt Co.	Colmar, Pa.
Gilde, L. C.	Campbell Soup Co.	Camden, N. J.
Grey, J. R.	Pennsylvania Canners Association	York, Pa.
Hamrick, J. L., Jr.	Virginia Water Control Board	Richmond, Va.
Hart, W. J., Jr.	John H. Dulany & Son, Inc.	Fruitland, Md.
Haut, I. C.	Agricultural Experiment Station	College Park, Md.
Highlands, M. E.	Agricultural Experiment Station	Orono, Me.
Hinds, M. K.	Federal Extension Service, U.S.D.A.	Washington, D. C.
Hoover, S. R.	Eastern Utilization Research Branch	Philadelphia, Pa.
Huffington, J. M.	Continental Can Co., Inc.	Baltimore, Md.
Hurley, J. M.	Wawa Dairy Farms	Wawa, Pa.
Jasewicz, L.	Eastern Utilization Research Branch	Philadelphia, Pa.
Johnson, J. F.	Francis H. Leggett & Co.	Landisville, N.J.
Johnstone, D. B.	Agricultural Experiment Station	Burlington, Vt.
Jones, W. E.	Federal Extension Service, U.S.D.A.	Washington, D. C.

Name	Organization	Address
Kahle, H.	Agricultural Marketing Service, USDA	Washington, D. C.
Kaplovsky, A. J.	Water Pollution Commission	Dover, Delaware
Katz, W. J.	Chain Belt Co.	Milwaukee, Wisc.
Kelley, E. G.	Eastern Utilization Research Branch	Philadelphia, Pa.
Knox, J. C.	New England Interstate Water Pollution Control Commission	Boston, Mass.
Kountz, R. R.	Pennsylvania State University	State College, Pa.
Lacy, H. R.	P. J. Ritter Co.	Bridgeton, N. J.
Lackey, J. B.	University of Florida	Gainesville, Fla.
Levowitz, D.	New Jersey Dairy Laboratory	New Brunswick, N.J.
Lothrop, R. E.	Eastern Utilization Research Branch	Philadelphia, Pa.
McMeekin. T. L.	Eastern Utilization Research Branch	Philadelphia, Pa.
McPhee, H. C.	Agricultural Research Service, USDA	Washington, D. C.
Massey, H.F.,Jr.	Agricultural Experiment Station	Lexington, Ky.
Merritt, D. S.	Campbell Soup Co.	Camden, N. J.
Milligan, F. B.	Department of Health	Harrisburg, Pa.
Monson, H.	Green Giant Co.	LeSueur, Minn.
Morris. R. H.	Eastern Utilization Research Branch	Philadelphia, Pa.
Oyler, J. R.	Knouse Foods Co-op., Inc.	Peach Glen, Pa.
Pfluger, R. A.	General Foods Corporation	Hoboken, N. J.
Porges, N.	Eastern Utilization Research Branch	Philadelphia, Pa.
Randle, S. B.	Agricultural Experiment Station	New Brunswick, N.J.
Ratchford, W. P.	Eastern Utilization Research Branch	Philadelphia, Pa.
Rohlich, G. A.	University of Wisconsin	Madison, Wisc.
Rue, J. W.	Tri-State Packers Association	Easton, Md.
Ryan, W. A.	New York State Canners & Freezers Association, Inc.	Rochester, N. Y.
Shelton, D. C.	Agricultural Experiment Station	Morgantown, W.Va.
Shreve, J.	Trappe Frozen Foods Corporation	Trappe, Md.
Siebert,C.L.,Jr.	Department of Health	Harrisburg, Pa.
Silbermann, H.	Water Pollution Control Commission	Baltimore, Md.
Somers, G. F.	University of Delaware Agric.Expt.Sta.	Newark, Del.
Steffen, A. J.	Wilson & Co., Inc.	Chicago, Ill.
Steinmetz, G. L.	H. P. Cannon & Son, Inc.	Bridgeville, Del.
Stone, R. W.	Agricultural Experiment Station	State College, Pa.
Strasburger, L.V.	Strasburger and Siegel, Inc.	Baltimore, Md.
Stumbo, C. R.	H. J. Heinz	Pittsburgh, Pa.
Thieme, R. W.	Water Conservation Board	Montpelier, Vt.
Thomas, H. R.	Office of Experiment Stations,ARS,USDA	Washington, D. C.
Thompson, E. C.	Dairy Industry Waste Disposal Committee	Brooklyn, N. Y.
Treadway, R. H.	Eastern Utilization Research Branch	Philadelphia, Pa.
Trebler, H. A.	Chemical Engineer	Baltimore, Md.
Twigg, B. A.	University of Maryland	College Park, Md.

Name	Organization	Address
Warrick, L. F.	Department of Health, Education and Welfare	Washington, D. C.
Weber, E.C.,Jr.	Water Pollution Control Commission	Baltimore, Md.
Weckel, K. G.	University of Wisconsin	Madison, Wisc.
Wells, P. A.	Eastern Utilization Research Branch	Philadelphia, Pa.
Wettlaufer, H.L.	P. J. Ritter Co.	Bridgeton, N. J.
Wiley, R. C.	Agricultural Experiment Station	College Park, Md.
Winkelblech, C.S.	New York State College of Agriculture	Ithaca, N. Y.
Woodward, C. F.	Eastern Utilization Research Branch	Philadelphia, Pa.